Figure 13.4 As the Concentrations of the Reactants Decrease, the Forward Reaction Slows Down

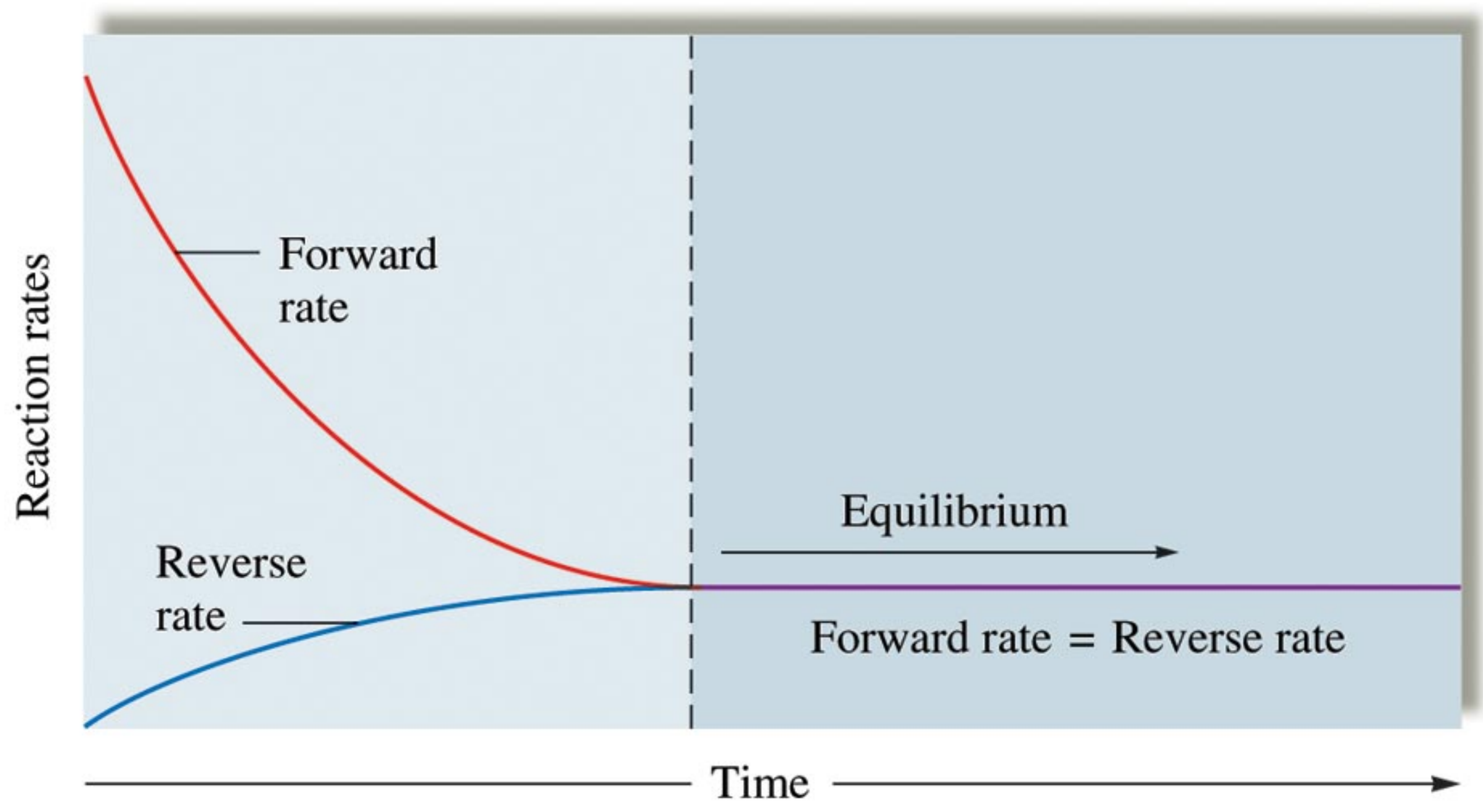


Figure 13.5 A Concentration Profile

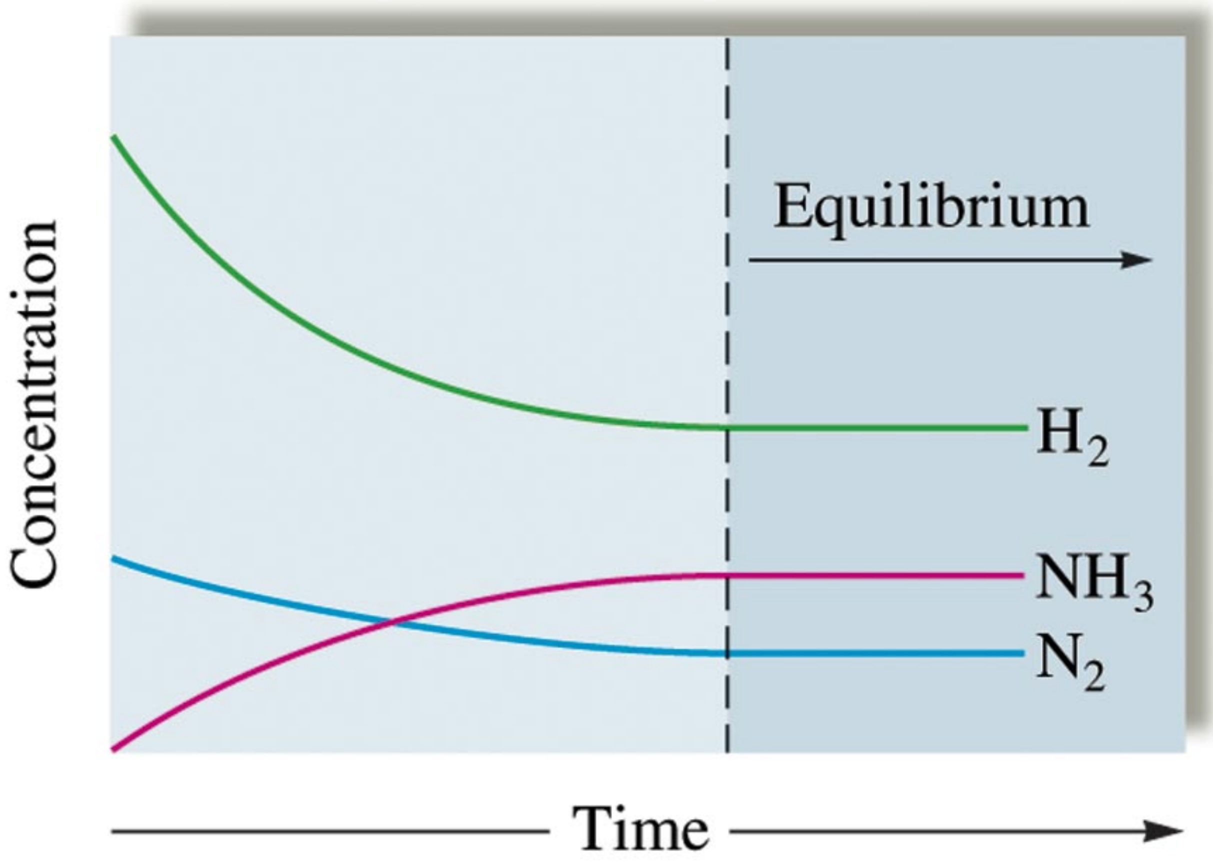


Table 13.1 Results of Three Experiments for the Reaction $N_2(g) + 3H_2(g) \rightarrow 2NH_3(g)$

TABLE 13.1 Results of Three Experiments for the Reaction $N_2(g) + 3H_2(g) \rightleftharpoons 2NH_3(g)$

Experiment	Initial Concentrations	Equilibrium Concentrations	$K = \frac{[NH_3]^2}{[N_2][H_2]^3}$
I	$[N_2]_0 = 1.000\ M$ $[H_2]_0 = 1.000\ M$ $[NH_3]_0 = 0$	$[N_2] = 0.921\ M$ $[H_2] = 0.763\ M$ $[NH_3] = 0.157\ M$	$K = 6.02 \times 10^{-2}$
II	$[N_2]_0 = 0$ $[H_2]_0 = 0$ $[NH_3]_0 = 1.000\ M$	$[N_2] = 0.399\ M$ $[H_2] = 1.197\ M$ $[NH_3] = 0.203\ M$	$K = 6.02 \times 10^{-2}$
III	$[N_2]_0 = 2.00\ M$ $[H_2]_0 = 1.00\ M$ $[NH_3]_0 = 3.00\ M$	$[N_2] = 2.59\ M$ $[H_2] = 2.77\ M$ $[NH_3] = 1.82\ M$	$K = 6.02 \times 10^{-2}$

QUESTION

For the reaction:

$$2NH_3(g) \leftrightarrows N_2(g) + 3H_2(g)$$

a. Write the equilibrium expression.

b. Calculate the value of K_c from the following concentrations

   $[NH_3] = 3.1x10^{-2}M$, $[N_2] = 8.5x10^{-1}M$, $[H_2] = 3.1x10^{-3}M$

c. Using the above concentrations calculate the K_c value of for the reverse reaction

d. Calculate the Kc value for the following reaction:

$$1/2N_2(g) + 3/2H_2(g) \leftrightarrows NH_3(g)$$

Figure 13.6 a-b The Position of the Equilibrium

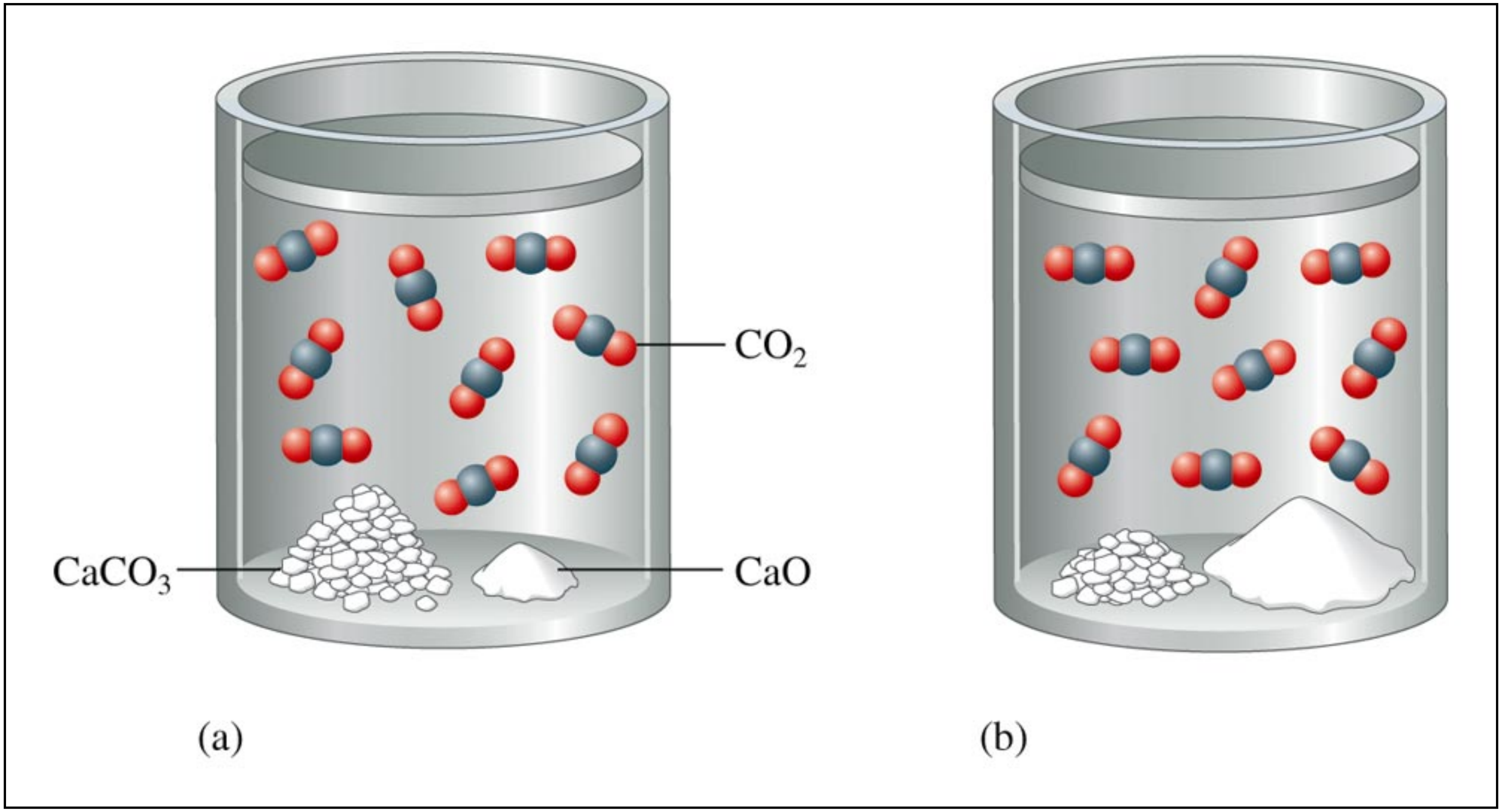
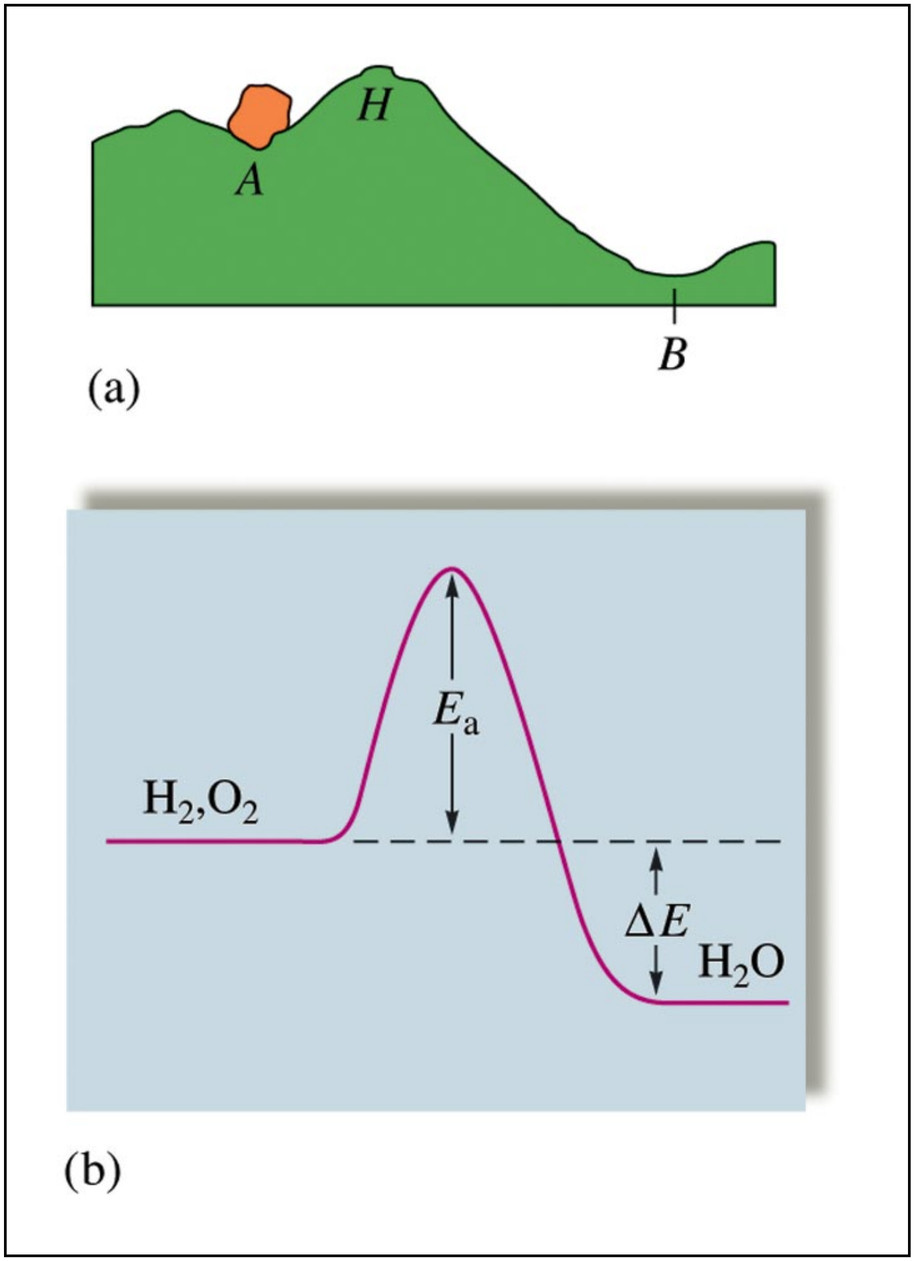


Figure 13.7 a-b The Size of K and the Time Required to Reach Equilibrium are not Directly Related as Shown Here



QUESTION

At a certain temperature, FeO can react with CO to form Fe and CO_2. If the K_p value at that temperature was 0.242, what would you calculate as the pressure of CO_2 at equilibrium if a sample of FeO was initially in a container with CO at a pressure of 0.95 atm?

$$FeO\ (s) + CO\ (g) \leftrightarrows Fe\ (s) + CO_2\ (g)$$

Ans = 0.19 atm

QUESTION

At elevated temperatures, NO gas will decompose via the following reaction: $2\ NO(g) \leftrightarrows N_2(g) + O_2(g)$ with a K value of approximately 1220. Starting with 0.10 M NO in a container, what would be the equilibrium concentration of N_2?

Ans = 0.049 M

QUESTION

Assume that gaseous hydrogen iodide is synthesized from hydrogen gas and iodine vapor at a temperature where K_p is 1.00×10^2. Suppose HI at 5.00 atm, H_2 at 0.100 atm, and I_2 at 0.0500 atm are mixed in a 5.000 L flask. Calculate the equilibrium pressures of all species.

$P_{H2} = 0.455$ atm
$P_{I2} = 0.405$ atm
$P_{HI} = 4.29$ atm

QUESTION

The weak acid $HC_2H_3O_2$, acetic acid, is a key component in vinegar. As an acid the aqueous dissociation equilibrium could be represented as

$$HC_2H_3O_2\,(aq) \leftrightarrows H^+(aq) + C_2H_3O_2^{\,-}(aq).$$

At room temperature the K_c value, at approximately $1.8\text{x}10^{-5}$, is not large. What would be the equilibrium concentration of H^+ starting from 1.0 M acetic acid solution?

Ans = $4.2\ \text{x}10^{-3}$ M

Figure 13.8 a-c (a) The Initial Equilibrium Mixture of N_2, H_2, and NH_3 (b) Addition of N2. (c.) The New Equilibrium Position for the System Containing More N_2 (due to Less H_2, and More NH_3 than in (a)

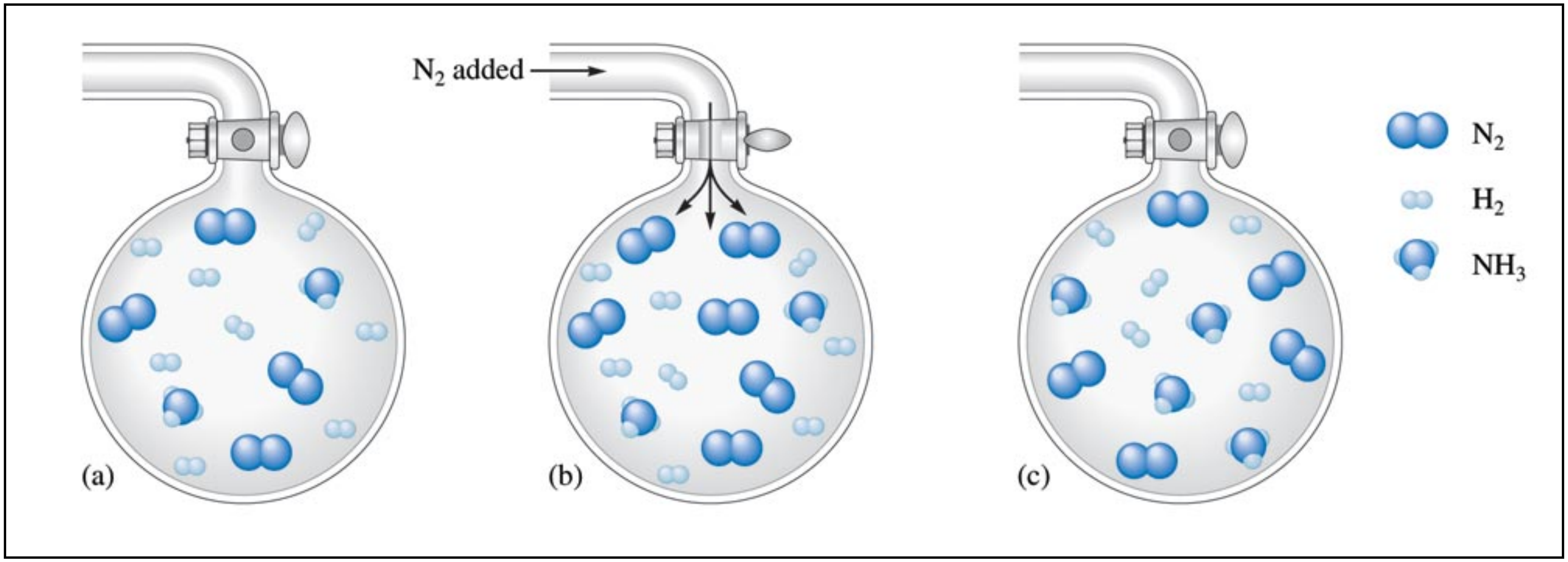


Figure 13.9 a-c (a) A Mixture of NH_3(g), N_2(g), and H_2(g) at Equilibrium (b) The Volume is Suddenly Decreased (c) The New Equilibrium Position for the System Containing More NH_3 and Less N_2 and H_2

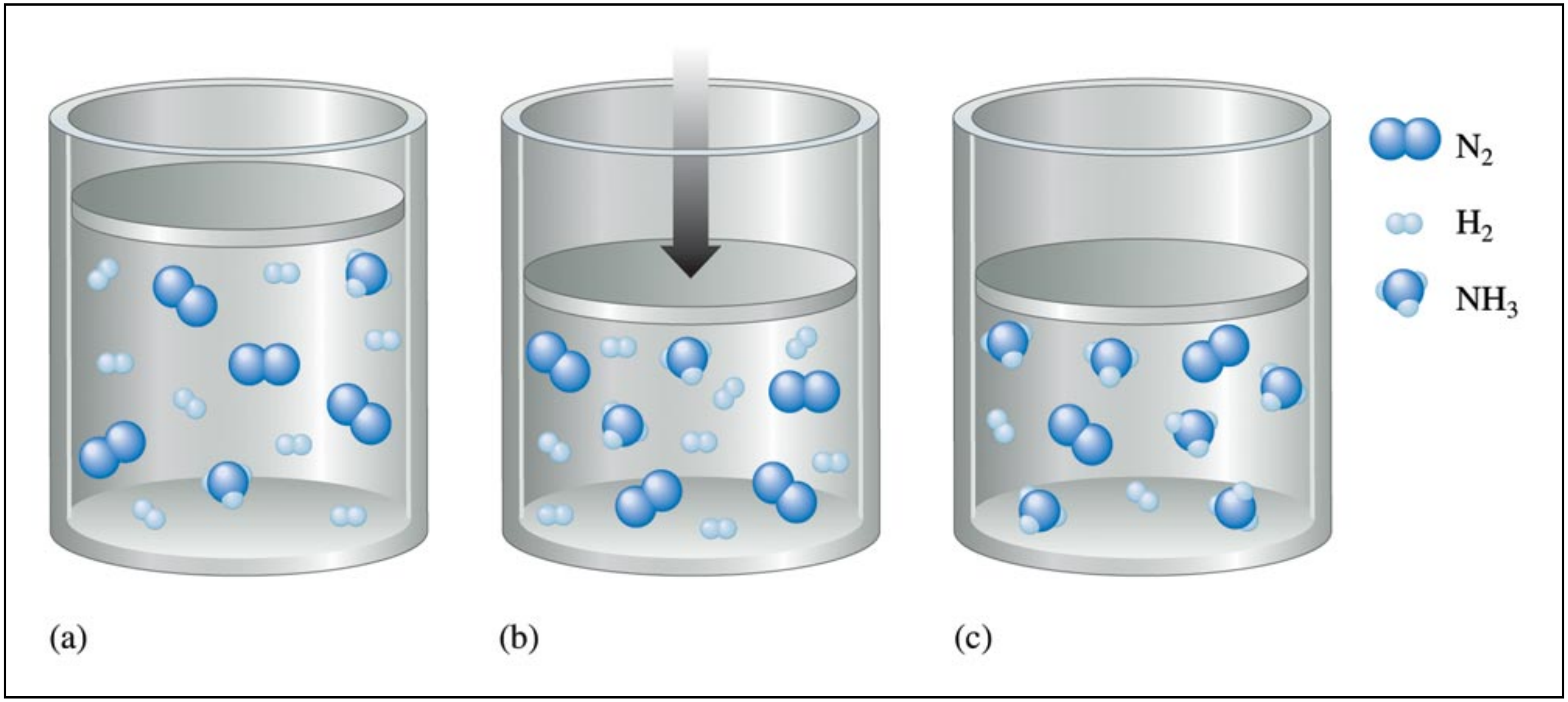


Photo 13.5 a-b LeChatelier's Principle II

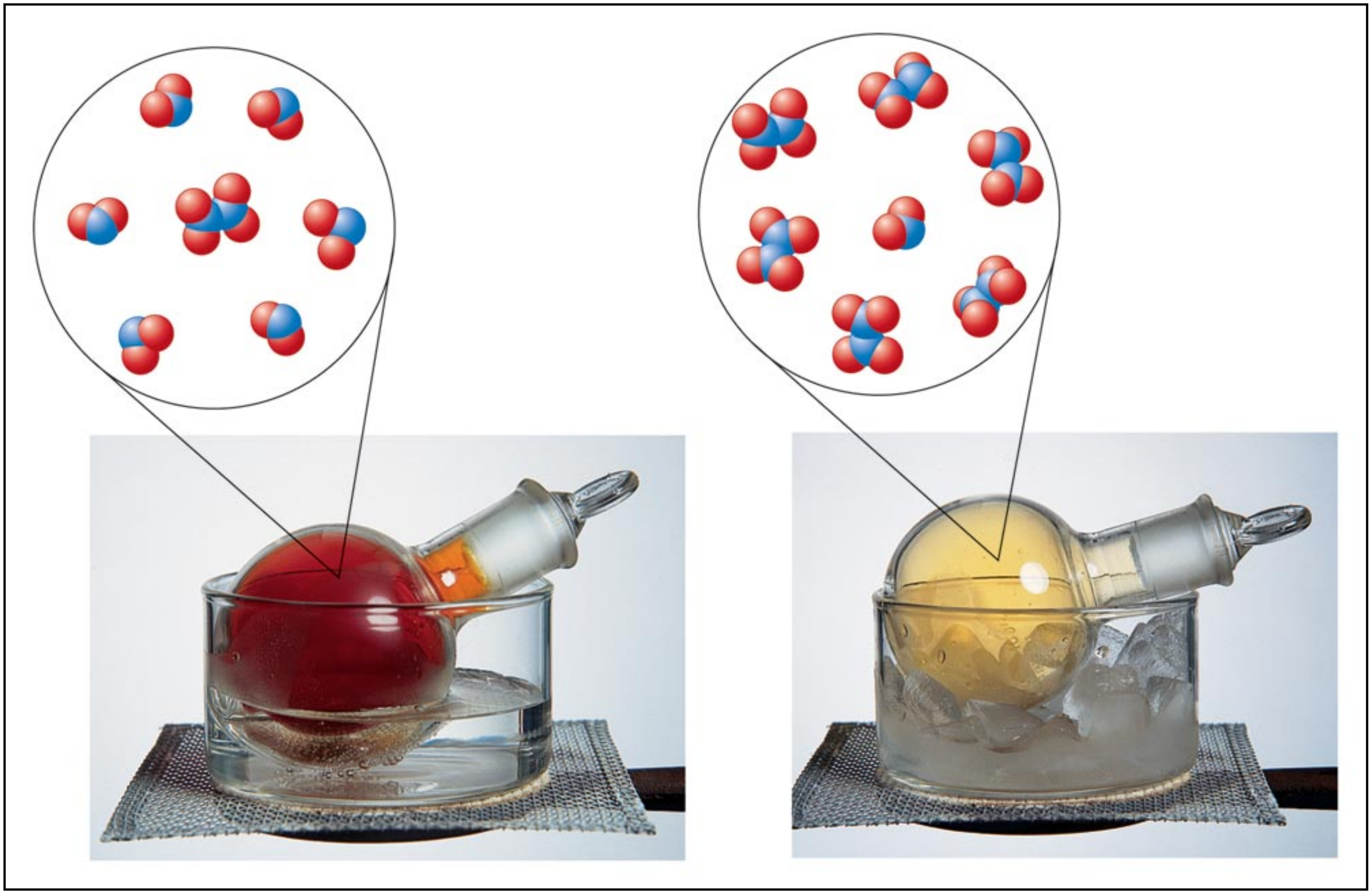


Table 13.2 The Percent by Mass of NH_3 at Equilibrium in a Mixture of N_2, H_2, and NH_3 as a Function of Temperature and Total Pressure

TABLE 13.2 The Percent by Mass of NH_3 at Equilibrium in a Mixture of N_2, H_2, and NH_3 as a Function of Temperature and Total Pressure*

	Total Pressure		
Temperature (°C)	*300 atm*	*400 atm*	*500 atm*
400	48% NH_3	55% NH_3	61% NH_3
500	26% NH_3	32% NH_3	38% NH_3
600	13% NH_3	17% NH_3	21% NH_3

*Each experiment was begun with a 3:1 mixture of H_2 and N_2.

Le Chatlier's Principle

$$As_4O_6(s) + 6C(s) \leftrightarrows As_4(g) + 6CO(g)$$

Predict the direction of the shift in of the equilibrium position in response to each of the following changes in conditions

a. Addition of CO

b. Addition or removal of $As_4O_6(s)$

c. Removal of gaseous arsenic

Table 13.3 Observed Value of K for the Ammonia Synthesis Reaction as a Function of Temperature

TABLE 13.3 Observed Value of *K* for the Ammonia Synthesis Reaction as a Function of Temperature*

Temperature (K)	*K*
500	90
600	3
700	0.3
800	0.04

*For this exothermic reaction, the value of *K* decreases as the temperature increases, as predicted by Le Châtelier's principle.

$58\ kJ + N_2O_4(g) \leftrightarrows 2NO_2(g)$

TABLE 13.4 Shifts in the Equilibrium Position for the Reaction $58\ kJ + N_2O_4(g) \rightleftharpoons 2NO_2(g)$

Change	Shift
Addition of $N_2O_4(g)$	
Addition of $NO_2(g)$	
Removal of $N_2O_4(g)$	
Removal of $NO_2(g)$	
Addition of $He(g)$	
Decrease container volume	
Increase container volume	
Increase temperature	
Decrease temperature	